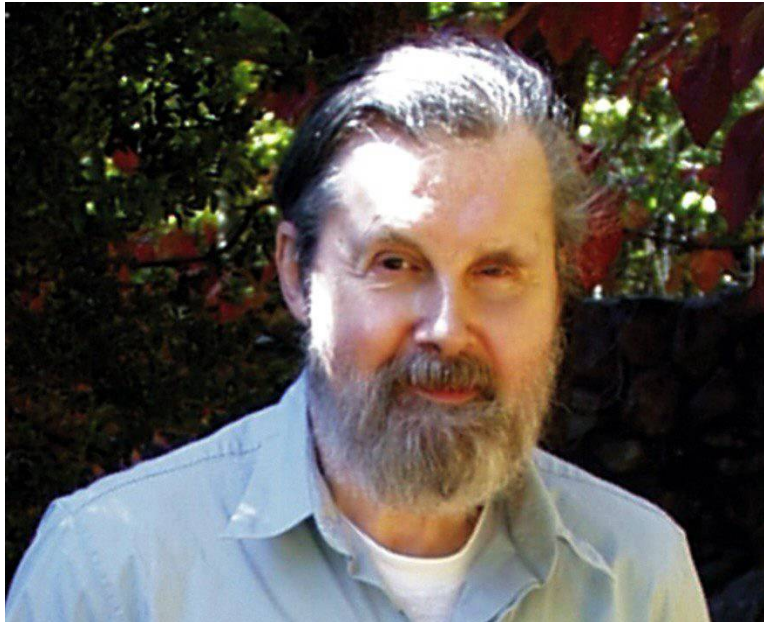


BARRY EARL TURNER (1935-2008)



Barry Turner in 2006 (NRAO photo)

Barry Earl Turner was born in Victoria, British Columbia, Canada on 8 September 1935, the elder son of John (“Jack”) Turner and Elsie Hazel (Hocken) Turner. Barry lived for two early years in Halifax, Nova Scotia while his father served on convoy duty in the Royal Canadian Navy during World War II. After the Turner family returned to Victoria in 1942, Barry attended Sir James Douglas Elementary School and Victoria High School.

Barry thrived in school despite a visual impairment that affected his depth perception as a child but was later corrected by contact lenses. As well as showing an early aptitude for, and strong interest in, mathematics and science he also excelled in training as a classical pianist. He began to take piano lessons at age 5 and went on to reach Grade 10 of the Toronto Conservatory of Music's program. After winning a piano competition in Victoria in 1948 he was asked by a local newspaper to describe his future goals. Barry's answer showed remarkable clarity about his intended career path and proved to be prophetic:



BARRY TURNER

“My aim is to become an astronomer. I think this would be a very interesting profession and it would also be of use to science. I have heard it takes much knowledge in mathematics and as I am interested in that at school I would not mind studying for this profession. I will probably have to go down to California to enter college and therefore it will cost a lot of money. I will most likely have to work towards earning this money. But in spite of all the difficulties in the way I would still like very much to become an astronomer.”

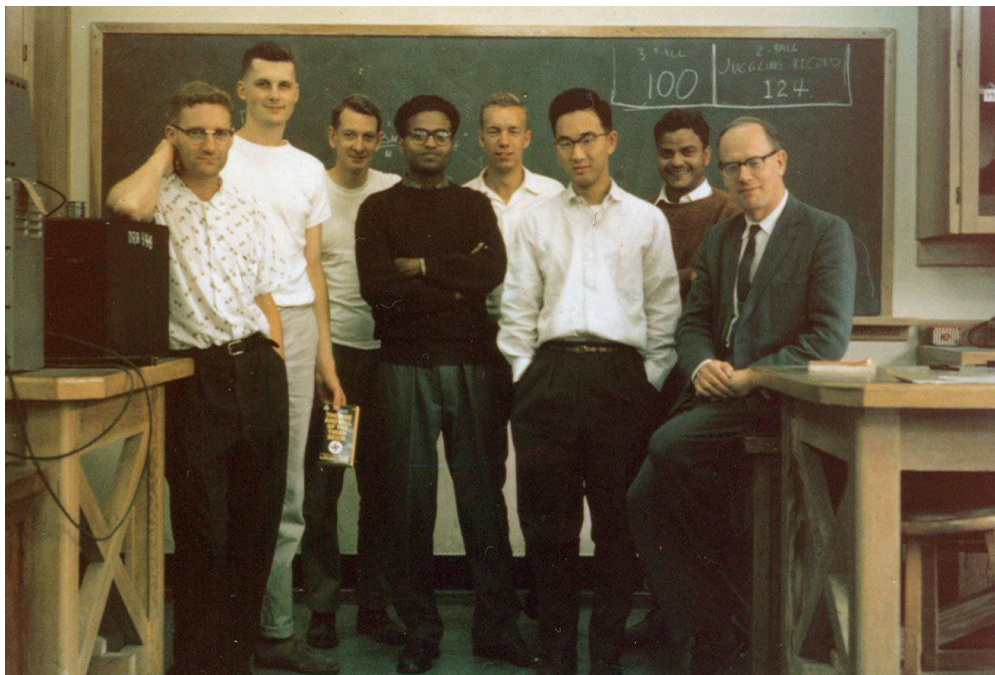
Barry is 13, in grade 7 and lives at 1243 Oscar St.

1948 local news report of Barry winning a piano competition

“My aim is to become an astronomer. I think this would be a very interesting profession, and it would also be of use to science. I have heard it takes much knowledge in mathematics and as I am very interested in that at school I would not mind studying for this profession. I will probably have to go down to California to enter college and therefore it will cost a lot of money. I will most likely have to work towards earning this money. But in spite of all the difficulties in the way I would still very much like to become an astronomer.”

- Barry Turner, age 13

One of his first summer jobs as a student was at the C.I.L. Defense Industries TNT factory on James Island in the Haro Strait (about 2.5 km off the East coast of Vancouver Island). This early exposure to industrial chemistry may have helped to spark his lifelong interest in the interface between physics and chemistry.



Barry Turner (second from left) and fellow graduate students in the solid state physics lab of Professor R.E. Burgess (far right) at the University of British Columbia.
Photo provided by Henry Bradford (first on left)

Barry next attended the University of British Columbia (UBC) in Vancouver, where he met Margaret-Anne Gourlay who he married in September 1961. After obtaining his B.Sc. with Honours in Physics there in 1959 he went on to work for his Master's degree in the laboratory of Professor Ronald E. Burgess, a British-born specialist in solid state physical electronics. Burgess instilled in his students a firm grasp of the complementary roles of theoretical analysis and laboratory instrumentation for investigating physical systems: a grasp that became one of the defining characteristics of Barry's professional career.

Barry's thesis on "Noise in the Tunnel Diode" was accepted for his Master's degree on August 3 1962. His first published paper was "Direct Tunnel-Current Noise in Tunnel Diodes for Small Biases" co-authored with Burgess in the Canadian Journal of Physics, Vol. 42, pp. 1046 - 1057 in June 1964. Barry's interest in astronomy and work on electronics led to his hiring as a research assistant at the Radio and Electrical Engineering Division of the National

Research Council of Canada (NRC) in Ottawa in 1962. Barry worked there for 15 months with Dr. Tom Legg on instrumentation for a solar interferometer array at what later became the Algonquin Radio Observatory. One of his tasks was to research, buy, and then test tunnel diode amplifiers to be used in the solar array's receivers

Barry's stated intention while at the NRC of Canada was to enter the Ph.D. program in the Department of Astronomy at the University of Toronto. He was therefore dismayed to learn that this university would not give him full credit for his completed physics courses at UBC. After learning that he would be asked to repeat their equivalents at Toronto he made a bold decision that profoundly affected the rest of his professional life and began his career in astrochemistry in the USA - he instead enrolled as a Ph.D. candidate at the University of California at Berkeley to work under the supervision of Professor Harold F. Weaver.

Barry did his Ph.D. Research in a group that was studying the newly-recognized radio signature of the hydroxyl radical in interstellar gas. His first published astronomical paper appeared in 1966: "Einstein A Coefficient for the Λ Doublet Transitions of the Ground State of OH", *Nature*, Volume 212, pp. 184-185 (1966). He took special pride in this theoretical paper, which corrected one of the few known errors in the famous text "Microwave Spectroscopy" by Nobel laureates Charles Townes and Arthur Schawlow. He also retained a lifelong interest in observing the OH radical in the interstellar medium.

On graduating from Berkeley he came to the National Radio Astronomy Observatory (NRAO) in Charlottesville, Virginia as a post-doctoral fellow in September 1967 and remained on the scientific staff there for the rest of his career. He had arrived at the NRAO at a time of very rapid development of radio-frequency spectroscopy of the interstellar medium. Radio emissions from water, ammonia, formaldehyde and carbon dioxide were all discovered in short order, showing that the interstellar gas in the Milky Way is, as Barry put it in a public outreach movie for the National Science Foundation in the 1970's, "teeming with interesting molecules".

Barry was ideally prepared to advance the new discipline of astrochemistry and he soon began to search for emission from more complex molecular species using the NRAO 140-foot telescope at Green Bank and later the 36-foot mm-wave telescope at Kitt Peak. While he often worked alone, he also collaborated with many other pioneers of the new field – including (in alphabetical order) David Buhl, Ed Churchwell, Frank Clark, Carl Heiles, Mark Morris, Pat Palmer, Bob Rubin, Lew Snyder, Lucy Ziurys and Ben Zuckerman.

While Barry visibly enjoyed working with the other pioneers of astrochemistry, in an era of increasingly large scientific collaborations his career was notable for many of his most significant contributions being papers on which he was sole author. His solo papers were characteristically long, meticulous and scholarly, and when journal editors sent manuscripts to him for refereeing, they learned to expect a referee's report that might be longer and more detailed than the original paper.

Early work in astrochemistry was intensely competitive as it rapidly became clear that many new discoveries awaited the best prepared and most insightful observers. Barry was exceptionally well suited to become a leader in this field. He was intensely competitive in a positive way, always striving to make his next effort at anything his own "personal best". His detailed knowledge of methods both for calculating radiative properties of molecules and for

carrying out efficient radio astronomical observing combined with his rigorous intellectual discipline to make him a central pillar of the emerging new field. He became a leading authority on the molecular species in the interstellar gas of our galaxy and of others, on how the molecules are produced, and on how they radiate at radio frequencies.

Barry conducted several large searches designed to discover emissions from new molecular species. These searches resulted in many notable new detections, including deuterated water, several multiply deuterated species, ethyl alcohol, cyanoacetylene and vinyl alcohol. He also did extensive further work on the OH radical that had been central to his doctoral thesis. He completed a definitive survey of the hydroxyl molecule in our galaxy and then went on to identify, or contribute to identifying, fifteen new molecular species in the Milky Way and three in external galaxies. His discovery of emission from interstellar cyanoacetylene -- published in the *Astrophysical Journal*, Vol. 163, pp. L35-L39 (1971) -- jumped the new field from one wherein only two atoms heavier than hydrogen had been found in any interstellar molecule to one with a molecule including three carbon atoms and a nitrogen atom. This was an early signal that the topic of interstellar organic chemistry was ripe to be explored.

Barry also believed that it was necessary to understand why some molecules are *not* detected in different interstellar environments, so that documenting significant non-detections of different interstellar species is also important to astrochemistry.

As the number of molecular species known to radiate under interstellar conditions proliferated, Barry's priorities shifted towards using observations of the molecular emissions to diagnose physical conditions -- temperature, pressure, and density -- within the interstellar clouds, and hence towards understanding where and how the molecules are formed, whether in the gas phase or on the surfaces of interstellar grains. To this end he began a series of major surveys in which he observed multiple targets over a wide range of radio frequencies, then identified newly discovered radio features using laboratory studies done by his colleagues, along with complex calculations to estimate the precise frequencies at which proposed molecules should radiate.



Barry Turner (at right) with Mark Morris and Ben Zuckerman
at the NRAO 36-foot telescope on Kitt Peak in 1973

The earliest of these surveys was made with the NRAO 36-foot (later 12-meter) telescope on Kitt Peak at wavelengths near 3mm. The analysis of these data resulted in Barry's most

frequently referenced work. Barry also continued spectral surveys of limited extent at other frequencies, but he eventually returned to attempt a definitive survey at 2mm (130-170 GHz) using the revamped 12-meter telescope with a vastly more sensitive suite of receivers. Sadly, it was the analysis of this important and prodigious survey, which he saw as his ultimate legacy paper, on which Barry was working at the time of his death. (Thanks to a heroic effort by his NRAO colleague Tony Remijan the survey data were compiled, reviewed and placed into an on-line digital archive to make them available to all interested researchers, see *arXiv:0802.2273*).

The problem of interpreting molecular observations in terms of the physical conditions in the dust clouds of the Milky Way is challenging, and has proven impossible to solve in the most general sense. Barry took great satisfaction in having successfully developed a physical model for “translucent” dust clouds that are not too dense, generally quiescent and structureless, and contain a large number of detectable molecular species - allowing their physical conditions to be determined reliably. The completeness of the data for such clouds allows gas phase chemistry to be thoroughly tested in them. Barry’s model of these clouds was published in a series of thorough and detailed papers which he followed up by comparing new observations with his model’s predictions. In most cases such new observations have supported his interpretation, e.g., his paper “A Common Gas-Phase Chemistry for Diffuse, Translucent, and Dense Clouds?” published in *The Astrophysical Journal*, Vol. 542, pp. 837-860 (2000).

Barry greatly enjoyed travel and he ultimately carried out his research at many radio telescopes around the world as well as those operated by the NRAO in Green Bank and at Kitt Peak. These other telescopes included the Arecibo Telescope in Puerto Rico, the Nançay reflector in France, the 100-meter telescope at Effelsberg, Germany, the James Clerk Maxwell Telescope in Hawaii, the NRC of Canada’s 150-foot telescope at the Algonquin Radio Observatory in Ontario, and the NRAO’s Very Large Array in New Mexico.

He also served on committees designing or advising the operation of new radio telescopes in several countries, including France, China, Japan and Chile. His collaboration with French astronomers at the Meudon Observatory using the Nançay Radio Telescope proved to have long term implications. At a time when the French government was trying to decide on the future of the instrument Barry chaired a committee to review and advise on a renovation project. The committee recommended that the renovation go ahead, giving the telescope many more productive years as a research facility.

A singular disappointment in Barry’s long career was the failure to win final approval for building a 25-meter mm-wave telescope to be operated by the NRAO in Hawaii. Barry had responsibility for bringing the proposal document together and, with the NRAO Director, for presenting it to the U.S. National Science Foundation (NSF). Although this ambitious project gained the approval of the NSF, and was included in President Jimmy Carter’s FY 1981 budget proposal, funding for the telescope’s final design was never released and the project was shelved.

Barry authored over 200 published papers in the course of his career and became internationally recognized for the high quality and rigor of his work. As well as collaborations with researchers in the USA and Canada, he also worked and consulted with Chinese, Japanese, Korean and Soviet colleagues. He was a member of the International

Astronomical Union (I.A.U.), of the American Astronomical Society (A.A.S.) and of the International Union of Radio Science (U.R.S.I.)

Barry's intense dedication to his science was legendary at the NRAO. In addition to working normal hours both on weekdays and on weekends, he usually returned to the observatory every evening after dinner at home, then stayed in his office or working in the computer room well beyond midnight before going home to end his day relaxing by playing his Petrof grand piano. (Characteristically combining theory and practice in a subject that was dear to him, Barry not only continued to play his piano regularly but also became an expert on the engineering design of grand pianos.)

Barry's dedication to science is also exemplified by a story related to me by his colleague Pat Palmer:

"We were observing on one occasion when the tail end of a hurricane hit Kitt Peak. The heavy downpour brought our program to a halt. We had to close the radome to keep the rain off of the electronics. During the peak of the rain, the rest of us returned from a meal to find a sleepless Barry stoically carrying on observing by himself. He was scanning through the receiver band with the telescope pointed through the side of the radome, just in case there was a previously unknown maser line somewhere in the tuning range of the receiver. Because of the losses in the atmosphere and especially in the wet radome, any such line would have had to have been as strong or stronger than any known line, but Barry was determined to test that possibility."

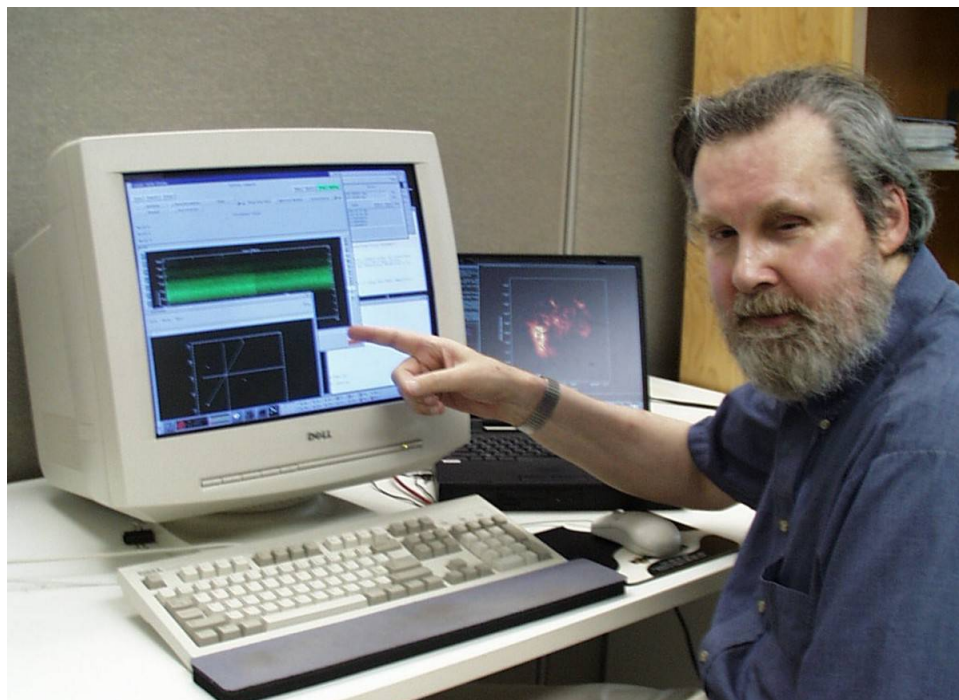
Having once suffered the effects of a disastrous fire in the NRAO office that he shared with Gerrit Verschuur, Barry famously kept every scrap of paper, IBM punched card, or magnetic data tape that had ever been in any way relevant to his research. His second office eventually filled with floor-to-ceiling piles of accumulated "treasures" that only he could navigate. This led to speculation that he was researching gravitational collapse by trying to induce it. (Late in his career it was found that the basement of his home contained a comparable accumulation, stored separately from his NRAO office for additional safety.)

Barry took great interest in the careers of young astronomers who he came into contact with. Nowhere was this more evident than his work on the oversight committee for the Experimental Program to Stimulate Competitive Research (EPSCoR) at the University of Kentucky, a federally-funded program which the state of Kentucky exploits to build a statewide infrastructure to promote national research competitiveness. At the time of Barry's death, the director of the Kentucky Space Grant Consortium, Karen Hackney, wrote that:

"Barry Turner was a beloved member of the Kentucky NASA EPSCoR External Review Panel. He was a dear colleague who served the interests of the Program for over a decade, journeying to Kentucky to shape and guide the NASA research. He brought advocacy for fundamental research while being cognizant of the needs for advancement of economic development thus providing a balanced portfolio of research for the Program. He has touched the lives of many faculty and students here. Students whom he helped get started have grown to be faculty who are nurturing students of their own. The good he has done has grown and is multiplying and will continue."

Barry was an avid runner and he also enjoyed sports both as a participant (to the extent that

he could with his visual issues) and as a spectator. He enjoyed watching ice hockey, football, baseball, soccer and rugby. He also took a great interest in detailed reports of high level chess matches. He was renowned at the NRAO for his enthusiasm for placing, and his success in winning, sports bets with his colleagues. A recurring ritual was a bet he placed annually with Bob Brown on the winner of the American League baseball pennant. Barry, who despised the New York Yankees, always bet on them to win the pennant, saying that he would be happy if they lost – but that if they won, then Bob Brown would owe him a pizza.



Barry Turner in 2005 (NRAO photo)

Sadly, the onset of an aggressive form of Parkinson's disease brought an untimely end to Barry's scientific career in late 2006. This debilitating, and ultimately fatal, condition became in some ways a new research project for him as he engaged his medical providers in debate about the mechanisms of the disease. He was eager to explore opportunities for innovative treatments, but his symptoms increased rapidly despite them. He continued playing his piano as long as he was able to, and listening to classical music remained a pleasure to him to the end of his life. In October 2007 he moved from his home in Albemarle County to the Martha Jefferson House Infirmary in Charlottesville, where he remained until his death on 10 May 2008.

Barry's wife Margaret-Anne Gourlay Turner survived him until 23 December 2014, one day before her 77th birthday. He is now survived by his brother Brian Neil Turner, sister-in-law Nelda, nephew Bruce and niece Colleen, all of whom live in British Columbia, Canada.

Biography by Alan Bridle, with the assistance of recollections of Barry's life from Henry Bradford, Bob Brown, Karen Hackney, David E. Hogg, Tom Legg, Pat Palmer, Brian Turner and Ben Zuckerman.